

the compilation of monthly summaries and charts. The following special notes by the respective keepers are extracted from these reports:

*Big Sandy Creek, Lake Ontario.*—10th, during the fore part of this night the northern lights were very brilliant; 14th, much damage by gale.

*Manistee, Mich.*—24th, sea was high and rough all day, but did not notice any current.

*Middle Island, Lake Huron.*—1st, northern lights 8 p. m.; 5th, northern lights about 8 p. m.; 9th, 8.30 p. m., northern lights; 11th, northern lights; 17th, northern lights 11.30 and continued after midnight; 18th, northern lights continued to 2 a. m.

*Oswego, N. Y.*—3d, had dim northern lights from 12 midnight to 5 a. m.; 9th, northern lights were plainly visible from 10 p. m. to midnight; 10th, bright northern lights from 12 midnight until 5 a. m.

*Point aux Barques, Mich.*—14th, barometer from 8 a. m. until 3 p. m. at 28.11, is the lowest it has ever been since being in use at this station (about 8 years); 28th, 11 a. m., first snow of the season.

*Point Betsey, Lake Michigan.*—17th, bright northern lights from 10 to 12. *Sturgeon Point, Harrisonville, Mich.*—13th, a heavy fog hung over the lake all day, the worst of the season.

*Vermillion Point, Lake Superior* [Post office, Whitefish Point, Mich.].—S. F. Bernier, keeper, reports, October 2d, at 3 p. m. the water in the Lake went down all at once 8 inches, and remained so for 15 minutes and then began to rise, and it rose 10 inches above the level and remained so for a few minutes (3 or 4), and then went down to its level and remained so for 30 minutes and again rose to 14 inches above the level and went down almost as quick and fell 18 inches below the level and it continued so till 8 o'clock that evening; the wind was southeast, fresh by spells, weather cloudy and occasionally rain, the wind shifting to the northwest, light at first at 8.30 p. m., thence increased to a gale by 12 o'clock, midnight. Barometer was falling very fast during the afternoon. 14th, this was the worst storm that we have had for years; the strongest wind and the biggest sea in my sixteen years on this station. 15th, the highest sea that ever was, it washed a solid bank of sand for one-quarter of a mile on to the land—took away our breakwater, pump-house, and look-out. 18th, white geese and ducks going south.

## NOTES BY THE EDITOR.

### THE COLD WEATHER STORMS OF INDIA AND AMERICA.

The cold waves that flow over the United States from the Northwest during the cold season, November to March, are analogous to the cold weather storms that occur in India during December, January, and February. These latter have been made the subject of study by the meteorological office at Calcutta, and an extensive memoir on the subject by J. Eliot, the superintendent of that office, has just been received, which will be of value to the students of American weather, and from which we extract the following paragraphs:

In India these storms occur during the prevalence of the northeast monsoon and they are of great economical importance, as the snowfall of the Himalayas occurs chiefly during their existence; they also give more or less rain to northern India. The character and value of the wheat and other crops of northern India largely depend upon the amount and distribution of the rainfall during these storms of the cold weather months. In some years the number of these storms is much less than usual and the rainfall scanty, and consequently the wheat crop fails more or less in the unirrigated regions; the more elevated the district the greater the failure. In other years these storms are of frequent occurrence and give moderate to heavy showers at short intervals; in such years the wheat crop of northern India is generally generous and there is usually a surplus available for export to Europe.

The cold weather storms originate during a period when dry land-winds prevail in India and when the lower atmospheric strata over northern India contain only from one-half to one-third the amount of moisture which is present in the air during the rains or southwest monsoons. A great variety of these storms march in an easterly direction across northern India, or in the opposite direction to that in which the cyclonic storms of the southwest monsoon period usually advance across northern India. They sometimes enter India from Baluchistan on the northwest and advance east or east-southeast across the whole breadth of India into Burmah, where they disappear either by filling up or by advancing into farther India where there are no meteorological observations at present available. They never enter India from the adjacent seas. On the other hand, the cyclonic storms of the rainy season generally enter India from the Bay of Bengal and move westward.

After giving a full description of all the more important cold weather storms during the sixteen years, from 1876 to 1891, Mr. Eliot says:

Cyclonic storms may originate under various combinations of circumstances, and any attempt to formulate a theory for all will necessarily fail to explain many important features of a special class. He arranges the storms of India as follows: (1) cyclonic storms of the southwest monsoon season; (2) cyclonic storms of the cold weather or northeast monsoon season; (3) storms of the hot season, including tornadoes, "nor'westers," thunderstorms, hailstorms, duststorms, etc.; these are usually of very small extent and rarely last more than a few hours.

The prominent features of the first class of storms are as follows:

- A. They form over the Indian Sea, and especially the Bay of Bengal.
- B. They move toward the west and north, and sometimes northeast, the mean direction being west-northwest.
- C. The central barometric depression is frequently very large and the winds very violent.

D. They give excessive rain, total falls of 15 to 20 inches being by no means unusual in the districts over which they pass.

E. The temperature changes are also small and are due to the rainfall.

The characteristics of the second class or cold weather storms are:

- a. They form in northwestern India or advance into that region from the plateaus and mountains of Persia, Afghanistan, and Baluchistan.
- b. They advance toward the east and east-southeast with great uniformity.
- c. A large proportion of the storms give rise to subsidiary depressions in the Punjab with very marked cyclonic features.
- d. The barometric depression in the primary disturbances is always small in amount, and the rainfall in the plains of northern India due to these storms is usually moderate in amount, rarely exceeding 3 or 4 inches.

e. The changes in temperature and humidity accompanying these storms are usually very marked. Every storm of importance is preceded in its advance across India by a warm wave and is followed by a cool and dry wave.

The first indication of a cold weather storm is usually a local fall of the barometer in Baluchistan, on the west frontier, and is followed by the appearance of a shallow depression on the northwest frontier; this latter drifts across northern India to the east or east-southeast and either fills up in northeastern India or passes farther eastward into Burmah. There is usually a considerable increase of temperature in front of the advancing depression; these depressions usually give light or moderate rain in their eastern and northern quadrants; little or no rain falls in the central area, and still less in the south quadrant. The effects of these storms are restricted to northern India, viz., from the north of the Deccan (between N. 20° and 35°).

In the majority of cases the appearance of barometric depressions on the west frontier is followed by the formation of deeper and smaller depressions to the northward in central and northern Punjab; these latter are usually almost usually stationary and fill up as rapidly as they form, while the previously existing shallow depressions to the southward are moving east to Bengal; the barometric changes in the Punjab, due to these deeper depressions, are occasionally very large and rapid; evidently the latter depend for their formation upon some atmospheric action connected with the eastward advance of the shallow depressions to the southward; they are, therefore, to be considered as secondary and subsidiary to them.

The subsidiary depressions in the Punjab are invariably accompanied by more or less heavy snowfall in the western Himalayas and in the Afghan mountains, and by moderate rain in the north and east Punjab; during their existence the heaviest and most extensive snowfalls in the hill districts of upper India, and the most general rain during the cold weather season in the plains of northern India usually occur. Out of a total of fifty-five primary storms or shallow depressions during the years 1876-1891, thirty were accompanied by secondary storms or depressions in upper India. The secondary are definitely related to the primary depressions, forming and disappearing during a well-defined stage in the progress of the latter, and their formation is almost certainly the result of special actions set up in the Punjab by the primary disturbances.

When there is a general decrease of pressure over the Indian area of north-east monsoons then the shallow primary depressions appear in northwestern India. There is an oscillation in the general pressure over this region which has a period of about five days in the cold weather season; this oscillation was particularly well marked in November and December, 1892, and was at that time almost simultaneous and uniform over a region extending a thousand miles in latitude and three thousand in longitude; hence the oscillations have the character of fairly regular pulsations and are not the result of any abnormal conditions, and are not likely to be due to the passage of waves of high and low pressure. Out of forty-four storms during the years 1878-1891, thirty-one formed or appeared in the northwestern frontier districts during that portion of barometric oscillation over the whole of India in which the barometer was falling, and only thirteen storms occurred when the barometer was rising, so that it is probable that the oscillatory decrease of pressure is favorable to the formation of the primary depressions of the cold weather storms; and, in fact, that these storms form within the areas of oscillatory depressions and probably, as a rule, not farther west than Baluchistan. An examination of the observations made in Persia shows that about one-third of these primary depressions are the continuation of depressions that had passed over central Persia three or four days before reaching the northwest frontier of India, so that in general out of forty-four storms during the years 1878-1891, seven apparently originated west of Baluchistan, nineteen in Baluchistan, and eighteen in upper or northwest India. Of those that have been traced back to central Persia, none can be clearly traced so far as Europe, and it is probable that the cold weather storms of India are not the continuation of European storms.

One of the most remarkable features of these storms is that a very large

proportion of them are double disturbances, consisting of a primary and secondary depression; the primary depression rarely exceeds 0.8 inch, and is usually 0.2. The secondary depressions begin to form when the primaries are entering or passing through Sind or west Rajputana; they vary much in importance but are generally deeper than the attendant primary depressions; it is only when a deep stationary secondary depression forms in the Punjab that strong stormy winds are experienced in the plains. These storms can not be ascribed to sea wind in the lower atmospheric strata. At the level of the plains the cyclonic circulation is feeble and somewhat irregular in the primary depressions, and the aqueous vapor which is condensed into rain is drawn from some upper current of the atmosphere and not from the lowest sea breezes. In the case of secondary depressions, although the winds may be stronger, yet it does not appear that the depression is maintained by vapor drawn from the lower strata, and Eliot concludes that for both these primary and secondary depressions the cyclonic circulation is chiefly developed and maintained by the middle and possibly a higher atmospheric strata, probably between 10,000 and 25,000 feet. Hence they are storms of high elevation and higher than the storms of the southwest monsoons proper, and the movement of the air at the level of the plains is comparatively feeble and of no importance so far as the maintenance of the indraught and the storm is concerned.

With regard to temperature: (a) each primary storm is preceded by a warm wave and the increased temperature occurs chiefly during the night, as shown by the morning minima; (b) the area of the warm wave precedes the storm-center by about twenty-four hours, so that the barometric depression on any day covers the area of greatest excess of temperature of the previous day; (c) these temperature features are almost certainly due chiefly to the effect of a thin veil of cloud or haze in the outskirts of the advancing storm in obstructing terrestrial radiation at night; (d) the increased temperature in front is determined by the advancing storm, and is a resultant of actions set up by the storm. Within the storm area itself the temperature conditions depend in part upon the amount of clouds and in part upon the occurrence of rainfall. The effect of moderate or thick clouds is to diminish the temperature of the lower air and the earth's surface by day and increase it by night. The effect of rainfall is of considerable importance, as it cools the lower air in its descent, and also cools the ground.

A cool wave usually advances India in the rear of each primary depression. Very clear, bright weather obtains in the rear of these storms, but the maximum day temperature continues for some days more or less below the normal, while the night temperature falls very rapidly. During the strong westerly winds that prevail for one, two, or three days after the passage of these storms the day temperature is more largely in defect, as compared with the normal, than the night temperatures. The mean temperature of the day after the passage is usually from 3° to 14° below the mean temperature of the day previous. The reduction of temperature appears to be mainly dependent upon the amount of snowfall during the storm and the height at which the snowfall remains unmelted on the mountain sides. The cooling effect is directly related to the dryness of the air of the westerly winds in the rear of the storm, being greater as the air is drier. The phenomena of temperature in the hill districts of India differ considerably from those in the plains; at the hill stations, at the end of the storm the temperature is largely below the normal and considerable snow is on the ground; for the next few days the temperature rises very slowly, but as soon as the greater part of the snow has melted the temperature rises, with great humidity.

Eliot states that the phenomena of the cold waves in India suggest that the air is usually cooled as it descends from the high land of Baluchistan, Afghanistan, and the western Himalayas; after cooling it descends; after descending it spreads southward as a comparatively thin stratum over the earth's surface. The temperature of the descending mass has been mainly determined by the elevation at which the snow is lying on the mountains and plateaus. The cool stratum is generally too shallow to surmount the western ghats or to pass over the Satpura Mountains, hence the cooling effects are not felt in the Deccan.

With regard to atmospheric moisture, its variations during the progress of the storms are generally excessive; there is a slight increase in absolute and relative humidity in front of the storm and a large increase when rain has fallen in advance of the storm, but a very large and rapid decrease immediately following the passage of the storm; this effect is transmitted eastward from the northwest frontier at a rate that is practically identical with the advance of the storm. The formation of cloud occurs chiefly in the eastern and northern quadrants; the cloud canopy frequently extends from four to eight times as far in front as it does in the rear; in front of the storm the changes from light cirrus to thick nimbus or pallium occur much as they do in European cyclonic storms; to the west of the center the cloudiness diminishes rapidly, and occasionally terminates almost abruptly in a sharp line beyond which the cloudless skies are unusually bright and clear; there is a special development of cloud in the northern quadrant over the Himalayas.

Rain occurs in northern India almost exclusively during these storms or depressions; the rainfall occurs chiefly in the northern and eastern quadrants of the primary depression; it is small in the central area and the south and west quadrants; the rainfall very frequently accompanies thunderstorms, and is therefore irregularly distributed; when a primary gives rise to a secondary depression in the Punjab the rainfall is much greater in that region than in any other part of northern India; in general, the rainfall during the double disturbances is nearly twice as much as during the single ones; the rainfall increases in amount as you go from the center of the depression northward to the foot of the hills, where it is ten times as large as near the center, thus show-

ing the very great influence exerted by the Himalayas; these storms give to the Himalayas a heavy snowfall, which not uncommonly amounts to 40 or 50 feet in the middle ranges and interior districts of that range of mountains.

The single disturbances or cold weather storms that have a primary but no secondary depression, are those whose tracks pass over the most northern portion of India; they give little or no rain to the plains of upper India; they move nearly due east, and within two days after their appearance in Sind they break up over the Himalayas, the mean rate of motion being 350 miles a day. The second class of storms, viz., those accompanied by secondary depressions, pursue tracks lying farther to the south and pass from the northwest frontier between N. 25° and 30° eastward over the whole breadth of northern India, the majority passing into Burmah at an average rate of 350 miles a day.

The comparison of successive years shows that the number of depressions varies very much; sometimes they succeed each other at the rate of from two to four in a month, at other times not more than one or two occurred during a whole season. The characters of the depressions vary largely; in some years they are almost exclusively shallow, primary depressions without secondaries; in other years they are to a great extent double disturbances and bring abundant rain to the plains and heavy snow on the hills; the tracks for any season are fairly persistent throughout the whole, being in one year more northerly and moving more directly easterly than in another year. The consequent irregularities in quantity and distribution of rain and snow during the cold weather season considerably exceed the irregularities of the rainfall during the southwest monsoon. The antecedent conditions that determine the character of these cold weather storms for any year are probably to be sought, not at a great distance, such as Europe, but in the Indian monsoon area and the adjacent regions. Eliot enumerates seven such possible antecedent characteristics of the monsoons, and gives a brief summary of the facts for and against the hypothesis that each of these is an important factor that could be utilized in forecasting the general character of the cold weather. One of these seems to be a matter of importance, namely, the relation between changes of pressure in the atmosphere at the lower level of the plain and at the upper level of the hills in northern India. Eliot shows that in the great majority of cases the cold weather rains have been heavier, or excessive, when the pressure at the upper level is below the normal, as computed on the basis of the pressure at the lower level, and on the other hand that the rainfall has been deficient when the pressure at the upper level is greater than the normal; apparently an excess of pressure at the high level stations means an excess in the middle atmospheric strata over northern India.

The data for 1876-1891 show conclusively that large vertical pressure anomalies in northern India are always associated with large variations in the rainfall; negative anomalies accompany excess and positive anomalies deficient rainfall. As the vertical pressure anomalies, especially when large, are not only persistent but antecedent to the cold weather rainfall, they may therefore be utilized in November and December to forecast the probable character of the following cold weather rains.

The following conclusions are formulated by Mr. Eliot, viz.:

"(3) If the vertical pressure anomalies are persistently negative throughout October to December, it is very probable that the cold weather rains from December to March will be heavier than usual, and the weather on the hills especially stormy. (4) If the vertical pressure anomalies are persistently positive from October to December, it is very probable that the following cold weather rains, from December to March, will be light, and the weather on the hills less disturbed than usual. (5) Continued stormy weather during the cold weather season is almost invariably associated with a local deficiency of pressure in the middle atmospheric strata, or with large negative anomalies, and the amount of the precipitation varies, on the whole, with the magnitude of the anomalies. (6) Unusually fine and settled weather in the months of December, January, and February, is almost invariably associated with excessive pressure in the middle atmospheric strata, or with what may be called anticyclonic conditions at a high altitude, and the deficiency in the rainfall varies directly with the magnitude of the positive anomalies."

Mr. Eliot is finally led to frame a simple explanation as to the origin and nature of these cold weather storms, of which the following is a synopsis:

They are phenomena of the upper atmospheric currents over northern India; the lower air currents are comparatively shallow and their direction is largely determined by the geographical features of the country: the mean direction of motion of the upper current is from the south 85° west, which current is one of the larger features of atmospheric circulation which have been fully explained by Ferrel. The cold weather storms are large whirls generated in this upper current whose motion is rapid and remarkably steady in direction; the motion of the storms or storm-whirls is largely determined by the movement of the mass of air in which they are embedded; the mean direction of their advance is from a point north 75° west, which differs only 20° from the general motion above given for the upper current as south 85° west. The rate of advance of the cold weather storms is from 300 to 500 miles a day, and therefore much greater than that of the southwest monsoon storms, but probably comparable with the average velocity of that portion of the upper current with which they drift eastward. They resemble in several important features the cyclonic storms of Europe and the United States.

The primary depression of the barometer is a dynamical effect due to the larger whirl in the upper current, which is a humid current, and receives its largest supplies of aqueous vapor at this season of the year by the ascensional motion in the equatorial belt of the Indian Ocean. When the primary depressions are crossing Sind and west Rajputana the southerly humid winds

in the eastern quadrant of the advancing depression are directed toward the western Himalayas and are forced upward by that mountain mass. Hence these storms give more cloud or rain or snow to the hills than to the plains. This forced ascensional movement on the eastern flank of the western Himalayas, as determined by the peculiar geographical features of the Punjab, results in the formation of the local whirls and secondary depressions attending the primary whirls. The growth and existence of the secondary depression thus initiated depends upon the condition of the upper current and the location of the primary whirl; when the latter reaches central India or south-east Rajputana, the supply of humid wind is cut off and the secondary begins to disappear. As the primary whirls are features of a higher current the secondary whirls would also belong to this current, hence the position and motion of the secondary whirl would be determined mainly by the highest ranges of the mountains inclosing the Punjab. As the chief indraft is at considerable elevation, therefore strong cyclonic winds are experienced in the western Himalayas, while at the level of the plain the cyclonic winds are lighter.

Both primary and secondary depressions are most numerous during the months of January and February, when it is most probable that the upper currents in which they form are strongest and carry most vapor. Eliot finds that the above conclusions explain all the more important features of the distribution of the rainfall in the plains of northern India and the snowfall in the western Himalayas and the mountains of Afghanistan, and hence also the peculiar features of the cool, dry waves which advance across India after these storms. The explanation of the latter is similar to that advanced by the editor for the cool waves of North America, differing only in the importance assigned to special geographical conditions in relation to the snowfall to the north and west of northwestern India.

There appear to be certain residual effects related to the secondary depressions, but not to the primaries, and consisting of certain shallow slow-moving depressions, which Mr. Eliot thinks may be explained by the fact that the lower air circulation in a cyclone is much more easily broken up than the higher circulation; the former may be disintegrated by hilly ground, while the upper portion may continue intact.

Referring to the work done by Mr. Blanford and Mr. S. A. Hill on the connection between the southwest monsoon rains and the cold weather rains, Mr. Eliot shows that there is a marked tendency for deficient rainfall during the southwest monsoon in upper India to be followed by deficient rain or snow in the succeeding cold weather. It is this combination of failure of the cold weather rains, following upon failure of the preceding southwest monsoon rains, that has given rise to the great majority of droughts and famines in northwestern India. During fifteen years (1878-1892) there were seven in which the southwest monsoon rainfall, namely, from June to September, was deficient in the Punjab, and in five of these years the rainfall of the following cold weather period, December to March, was also deficient, and in four years very considerably so.

Mr. Eliot concludes that the further study of this subject must depend upon the preparation of daily charts over the little-known area between India and Europe, and perhaps the preparation of international charts for the Northern Hemisphere.

#### THE EFFECT OF GALES IN CAUSING HIGH WATER.

The influence of the wind and tide, and possibly the low barometric pressure of a storm area, in causing an unusual rise of water is the occasion of much of the damage and loss of life that attends the storms of the Atlantic and Gulf coasts. Observations tending to fix the extent of this high water and the special causes that produce it are always desirable. We submit herewith the records of water, wind, and pressure for two storms, viz., June 4 to 5, 1891, at Galveston, and October 12 to 13, 1893, at South Island, Winyah Bay, S. C. The latter was furnished by Gen. E. P. Alexander, and the former by Dr. J. M. Cline, of the U. S. Weather Bureau. Winyah Bay, having Georgetown, S. C., at its head, is subject to high water when east and south winds prevail; its mouth is about 50 miles northeast of the city of Charleston; it is therefore east of the path of the center of the hurricane of August 27, 1893, on which occasion the maximum height of the water was 9 feet above the zero of the gauge, which is approximately mean low water; on October 12-13, it lay nearly in the track of the hurricane center, and the maximum height of the water was 11.6 feet. Similar high water prevailed on both these dates along the middle and south Atlantic coasts; the official reports from Beaufort, S. C., by Lieutenant Cushing, of the Revenue Marine, show that about 500 persons were drowned in that region during the August hurricane.

The location of Galveston, on the inside or northwest side and at the northeast end of a long island and facing Galveston Bay on the north and west, is such that northeast and especially southeast winds cause an accumulation of water in the harbor, but not to such an extent as in many other places for two reasons, first, the large area of the harbor as compared with the size of its inlets, second, the fact that a portion of the water is usually flowing out of one opening while flowing in at another, so that the actual rise is the difference between the inflow and outflow. The storm-center of July 4-6 recurred just west of Galveston, so that that city experienced an unusually long continuance of northeast backing to southeast, and finally southwest winds; the greater rise of water occurred simultaneously with the northeast and southeast winds, but a rapid and decided rise and fall followed two hours after the maximum southwest wind in a well-marked sequence.

In Winyah Bay, under the influence of winds that were estimated at 90 miles, although doubtless the maximum velocity of the open sea may have exceeded this, the actual height of the water exceeded that due to the natural

tide by 7 or 8 feet between 2 a. m. and 9 a. m. of October 18th. At Galveston under the influence of easterly winds, whose measured velocity attained 44 miles, the maximum gauge reading was 4.6, and therefore less than 4 feet above the slight natural tide. At both these stations, therefore, the rise in the water surface attributable to the winds is in both cases about twenty times greater than the height of a column of water that can be sustained by such winds in statical equilibrium, as in the Lind anemometer, and this factor is only slightly diminished by making some allowance for the rise of water due to the diminished barometric pressure.

Observations during storms of June 4-5, 1891, at Galveston, Tex., and October 12-13, 1893, at South Island, S. C.

		Galveston, Tex.					South Island, Winyah Bay, S. C.				
1891.	Barometer.	Wind.		Actual water.	1893.	Barometer.	Wind.		Natural tide.	Actual water.	
		Direction.	Velocity.				Direction.	Velocity.			
July 4.											
Noon.	Inches		Miles.	Feet.	October 12.	Inches		Miles.	Feet.	Feet.	
1 p. m.	.....	.....	.....	2.1	8 a. m.	29.85	ne.	20	3.2	4.0	
2 p. m.	.....	.....	.....	2.3	9 a. m.	.....	ne.	.....	3.8	4.8	
3 p. m.	.....	.....	.....	2.2	10 a. m.	29.8	ne.	22	3.4	4.2	
4 p. m.	.....	.....	.....	2.0	11 a. m.	.....	.....	.....	2.7	4.0	
5 p. m.	.....	.....	.....	2.1	Noon	29.80	.....	24	2.2	3.4	
6 p. m.	.....	.....	.....	1.7	1 p. m.	.....	.....	.....	1.4	2.4	
7 p. m.	.....	.....	.....	1.6	2 p. m.	29.70	ne.	26	0.8	2.5	
8 p. m.	29.96	e.	20	1.3	3 p. m.	.....	ne.	.....	0.3	2.2	
9 p. m.	.....	e.	24	1.0	4 p. m.	29.70	ne.	28	0.5	2.2	
10 p. m.	.....	e.	24	0.8	5 p. m.	.....	.....	.....	1.0	3.0	
11 p. m.	.....	e.	24	1.0	6 p. m.	29.69	.....	32	1.5	3.6	
Night	.....	se.	26	1.2	7 p. m.	.....	.....	.....	2.4	4.8	
	.....	.....	28	1.7	8 p. m.	29.62	.....	42	1.9	4.8	
July 5.											
1 a. m.	.....	e.	30	2.3	9 p. m.	.....	.....	.....	2.8	5.3	
2 a. m.	.....	ne.	36	2.9	10 p. m.	29.50	ne.	52	3.2	6.4	
3 a. m.	.....	e.	36	3.4	11 p. m.	.....	ne.	.....	2.6	6.9	
4 a. m.	.....	se.	36	4.0	Night	29.48	ne.	58	2.0	.....	
5 a. m.	.....	ne.	27	4.4	October 13.						
6 a. m.	.....	.....	36	4.5	1 a. m.	.....	.....	.....	1.3	7.3	
7 a. m.	29.78	.....	44	4.6	2 a. m.	29.40	ne.	64	0.7	7.9	
8 a. m.	.....	.....	33	4.65	3 a. m.	.....	ne.	.....	0.2	8.2	
9 a. m.	.....	.....	4	4.4	4 a. m.	29.30	ne.	66	0.4	8.4	
10 a. m.	.....	ne.	17	4.1	5 a. m.	.....	.....	.....	0.9	8.5	
11 a. m.	.....	.....	6	3.8	6 a. m.	29.18	.....	72	1.5	8.6	
Noon	.....	se.	13	3.6	7 a. m.	.....	.....	.....	2.0	8.7	
1 p. m.	29.80	.....	17	3.6	8 a. m.	28.95	ne.	78	2.5	9.2	
2 p. m.	.....	.....	12	3.2	9 a. m.	.....	ne.	90	3.2	10.8	
3 p. m.	.....	.....	20	3.1	10 a. m.	.....	calm	calm	.....	11.6	
4 p. m.	.....	.....	20	3.0	11 a. m.	28.33	w.	66	3.7	11.3	
5 p. m.	.....	.....	24	2.9	Noon	28.95	w.	50	2.3	6.8	
6 p. m.	.....	.....	28	2.7	1 p. m.	28.95	w.	.....	1.6	5.2	
7 p. m.	29.62	.....	40	2.4	2 p. m.	29.16	w.	40	1.0	3.7	
8 p. m.	29.24	.....	60	2.1	3 p. m.	.....	w.	.....	0.5	2.3	
9 p. m.	.....	sw.	26	3.6	4 p. m.	29.30	w.	28	0.8	2.3	
10 p. m.	.....	.....	36	3.8	5 p. m.	.....	w.	.....	0.3	2.1	
11 p. m.	.....	.....	22	1.9	6 p. m.	29.40	w.	24	1.5	2.1	
Night	.....	.....	24	1.7	7 p. m.	.....	w.	.....	2.0	.....	
July 6.											
1 a. m.	.....	.....	27	1.7	8 p. m.	29.45	w.	22	2.5	.....	
2 a. m.	.....	.....	16	1.7	9 p. m.	.....	w.	.....	3.2	.....	
3 a. m.	.....	.....	21	1.9	10 p. m.	29.50	w.	20	3.7	.....	
4 a. m.	.....	.....	16	1.6							
5 a. m.	.....	.....	17	1.7							
6 a. m.	.....	.....	19	1.9							
7 a. m.	29.84	.....	24	2.4							
8 a. m.	.....	sw.	20	2.0							

NOTE.—The rainfall at Galveston, Tex., from July 4th, noon, to July 5th, noon, was 1.53 inches. The rainfall at South Island, S. C., from October 12th, 8 a. m., to October 13th, 8 a. m., was 4.5 inches.

The height of a column of pure water that can be sustained in statical equilibrium, as in the Lind anemometer, by the steady pressure of the wind is given in the following table; the height of a column of sea water would be about 3 per cent less:

Wind velocity, miles per hour.	Column of pure water, inches.
20	1.0
40	2.1
60	3.1
80	4.2
100	5.2
120	6.2

But in the free water of rivers, lakes, and oceans we have not to do with a static phenomenon; the water is free to move, and the first tendency of the wind to push the water on shore and pile it up is followed by a return underflow. The wind therefore pushes the surface water up a gentle slope as fast as the water in front at the top of the slope can sink to the ground and return by the undertow. There is an intermediate plane of no horizontal movement, which plane also has a gentle slope equal to about one-half or one-third of that of the surface water, and we must consider the wind as merely pushing surface water up this latter slope. The work that the wind does is simply to maintain a fairly steady flow up this slope until the surplus pressure at the upper end is just sufficient to overcome the resistances that accompany the

fairly regular return flow of the undertow, but as the wind is the ultimate motor power, we may say that the wind maintains the circulation of the water flowing toward the shore and then returning, and the force with which the wind would press against a stationary vertical wall of water is here converted into the work done in overcoming the forces that resist the movement of water. If the water surface is quite smooth then the principal resisting force that has to be overcome is the so-called viscosity, or internal friction of water flowing over water, but ordinarily this surface is thrown into waves and breakers which stir the shallow waters down to the very bottom and thus add another class of resistance called convective or vortex resistance.

SUMMARY OF OBSERVATIONS MADE BY WILLIAM DUVAL, VOLUNTARY OBSERVER, WEATHER BUREAU, AT THE WHALING STATION OF JOHN O. SPICER AT SIGNOWYA.

This station is apparently on a small island on the coast a little south of the

mouth of Cumberland Sound, in latitude N. 68° 28', W. 64° 30'. The height of the ground above sea-level is noted at 35 feet, so that the reduction of the barometer will be +0.04, but this correction has not been added.

The aneroid was compared with the Weather Bureau mercurial barometer at Washington and again at New London before Mr. Duval sailed from that port, about July 7, 1891, and it may be assumed that at that time its reduction to the standard was zero. The reduction of a mercurial barometer to standard gravity is -0.011 at New London and +0.048 at Signowya.

The thermometer had been properly verified. The air temperature, pressure, wind, and clouds were observed at 7 a. m., 2 p. m., and 9 p. m., daily, apparently on local time, which was also used for other records. The maximum and minimum temperatures were given by self-registering thermometers. Nothing is known as to the exposure of thermometers.

The wind force is recorded on a scale of 0 to 10.

The following table summarizes the results of Mr. Duval's observations:

Summary of observations at Signowya, Cumberland Sound.

Year and month.	Pressure.								Temperature.																				
	Mean.			Maximum.		Minimum.		Mean pressure, 7 a. m. + 2 p. m. + 9 p. m. ÷ 3.	Mean.			Maximum.		Minimum.		Mean maximum.	Mean minimum.	Mean temperature, 7 a. m. + 2 p. m. + 9 p. m. ÷ 3.											
	7 a. m.	2 p. m.	9 p. m.	Reading.	Date.	Reading.	Date.		7 a. m.	2 p. m.	9 p. m.	Reading.	Date.	Reading.	Date.														
1891.	Inches.	Inches.	Inches.	Inches.		Inches.		Inches.	°	°	°	°		°		°		°											
September .....	29.704	29.706	29.718	30.16	13	29.30	27	29.709	33.3	40.0	31.1	54	1	18	30	43.3	25.9	33.9											
October .....	29.550	29.553	29.550	29.92	6, 15	29.30	3, 10, 31	29.551	16.8	21.2	14.8	36	1, 9	12	31	23.2	11.5	16.9											
November .....	29.752	29.749	29.754	30.10	9, 28	29.40	1	29.752	-3.9	-2.7	-5.3	1	13	20	21	-2.5	-7.0	-4.3											
December .....	29.772	29.776	29.778	30.10	6, 7, 31	29.50	8	29.772	-17.5	-16.8	-17.9	6	1, 6, 8	26	22, 27	-16.6	-18.1	-17.5											
1892.																													
January .....	29.737	29.738	29.741	30.46	12	29.00	25	29.739	-9.2	-9.0	-9.5	40	6	26	28	-8.3	-11.1	-9.3											
February .....	29.950	29.948	29.952	30.72	21	29.32	24	29.950	-6.8	-6.7	-7.2	34	14	28	8	-6.6	-8.2	-7.0											
March .....	29.855	29.854	29.859	30.36	6	29.24	8	29.857	-0.9	-0.3	-1.0	18	10	16	18, 22	0.5	-3.6	-0.8											
April .....	29.904	29.911	29.911	30.40	9	29.42	1	29.909	13.1	14.1	13.1	36	19	8	7	14.4	11.2	13.3											
May .....	29.996	30.001	30.005	30.50	8	29.50	2	30.001	26.9	27.4	27.0	38	22, 27	8	5	27.5	25.2	27.1											
June .....	29.763	29.777	29.787	30.10	21	29.18	17	29.776	38.2	41.6	37.9	54	23	30	2, 10, 18, 28	42.7	35.3	38.9											
July .....	29.604	29.609	29.618	29.92	28, 29	29.02	18	29.612	37.5	41.5	38.3			26	18		34.1	38.9											
August * .....	29.637	29.623	29.636	30.02	11, 12	29.00	23	29.632	38.8	43.7	39.2			32	6, 7, 9		34.7	40.2											
Year and month.	Wind direction (number of times).								Wind force (number of times).										Precipitation.		Average cloudiness.		Number of days—						
	Calm.	South.	Southwest.	West.	Northwest.	North.	Northeast.	East.	Southeast.	Blank.	0	1	2	3	4	5	6	7	8	9	Blank.	Number of days.	Number of hours.	7 a. m.	2 p. m.	9 p. m.	Clear (0 to 1).	Cloudy (8 to 10).	Foggy.
1891.	0	1	8	7	22	26	25	0	1	0	0	2	18	16	15	12	7	16	4	0	...	7	100	49	47	46	10	10	.....
October .....	0	0	0	9	54	15	15	0	0	0	0	3	17	15	7	4	26	10	5	6	0	4	61	44	46	41	10	4	2
November .....	5	2	1	3	15	16	51	0	3	0	5	1	8	10	25	27	9	5	0	0	0	15	258	65	66	64	8	19	0
December .....	21	0	0	6	24	27	15	0	0	0	21	4	21	15	16	14	0	2	0	0	0	2	16	49	41	38	16	7	5
1892.																													
January .....	12	0	0	5	40	6	24	3	3	0	12	4	25	10	19	11	8	4	0	0	0	6	82	44	43	41	14	11	2
February .....	10	0	6	4	30	9	26	2	0	0	10	6	17	22	8	12	6	6	0	0	0	5	62	49	47	47	14	12	0
March .....	18	0	0	3	23	12	34	0	3	0	18	22	20	6	11	5	5	3	3	0	0	5	90	54	52	47	11	9	0
April .....	9	0	3	0	9	6	63	0	0	0	9	0	12	5	22	20	4	18	0	0	0	8	129	59	59	57	9	11	0
May .....	21	0	9	3	17	0	28	0	15	0	21	1	24	21	14	3	9	0	0	0	0	5	83	56	58	56	8	7	4
June .....	8	1	0	0	14	5	53	3	6	0	8	12	19	14	17	13	7	0	0	0	6	76	72	69	67	7	6	13	
July .....	19	5	10	2	4	1	32	6	14	0	19	25	22	12	6	3	1	3	2	0	0	9	116	56	62	60	12	5	11
August * .....	15	0	10	7	7	2	25	1	2	8	15	22	14	7	8	3	0	0	0	0	8	8	108	65	62	60	7	7	6

NOTE.—It is expected that the observations at this station for the years 1892, 1893, and 1894 will be received in the summer of 1894.

\* All data for August are for 23 days only.